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(54) **Microwave drying of granular materials**

(57) Screw-conveyor (6) extends axially within the shell to progress material from inlet (7) to the discharge (10) through several treatment sections, one of which is a microwave drying section (4). The portion of the screw-conveyor within the microwave section is made of a material, e.g. a plastics such as polypropylene, which has a low absorption for microwave energy and consequently does not substantially attenuate such microwave energy. The other sections can comprise firstly a steam/hot water heating section and secondly a materal cooling section, respectively upstream and downstream of the microwave section. The microwave section can be bounded by choke plates.

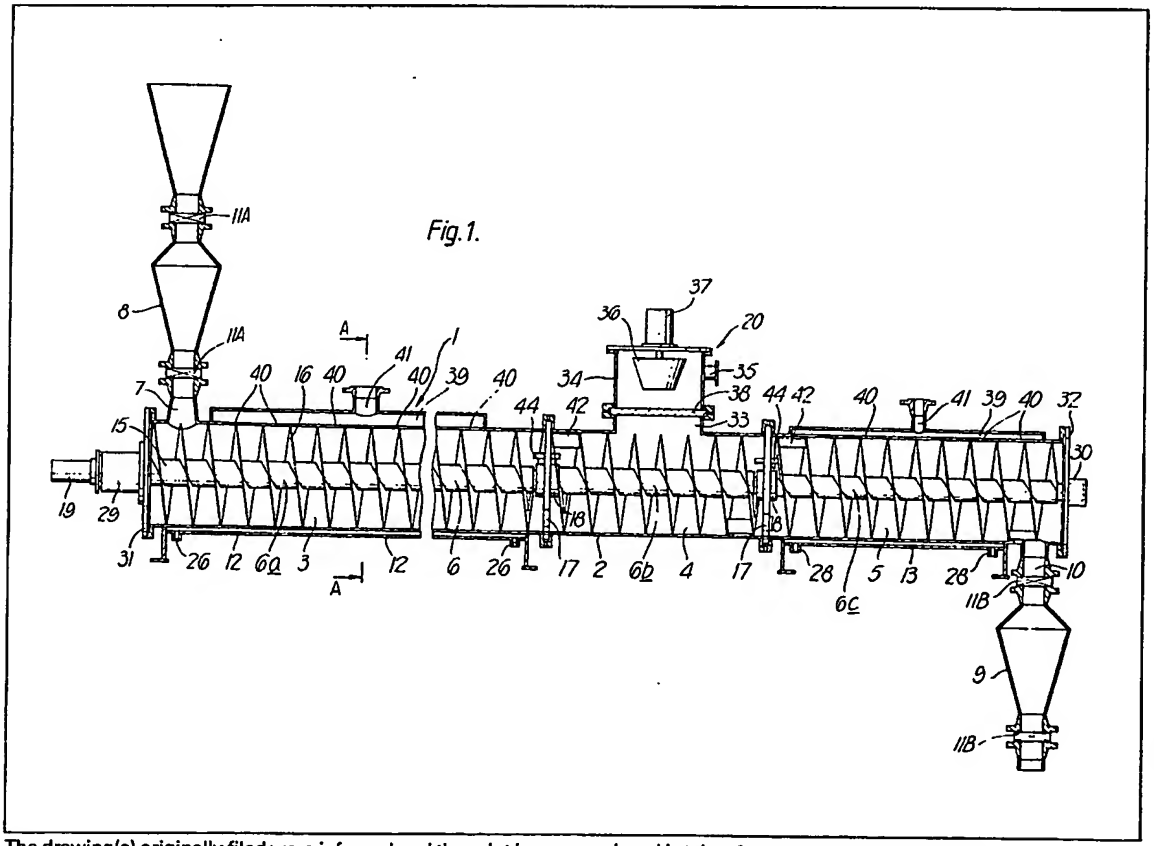

Fig.1.

GB 2 110 803 A

The drawing(s) originally filed were informal and the print here reproduced is taken from a later filed formal copy.
This print takes account of replacement documents later filed to enable the application to comply with the formal requirements of the Patents Rules 1978 or 1982.

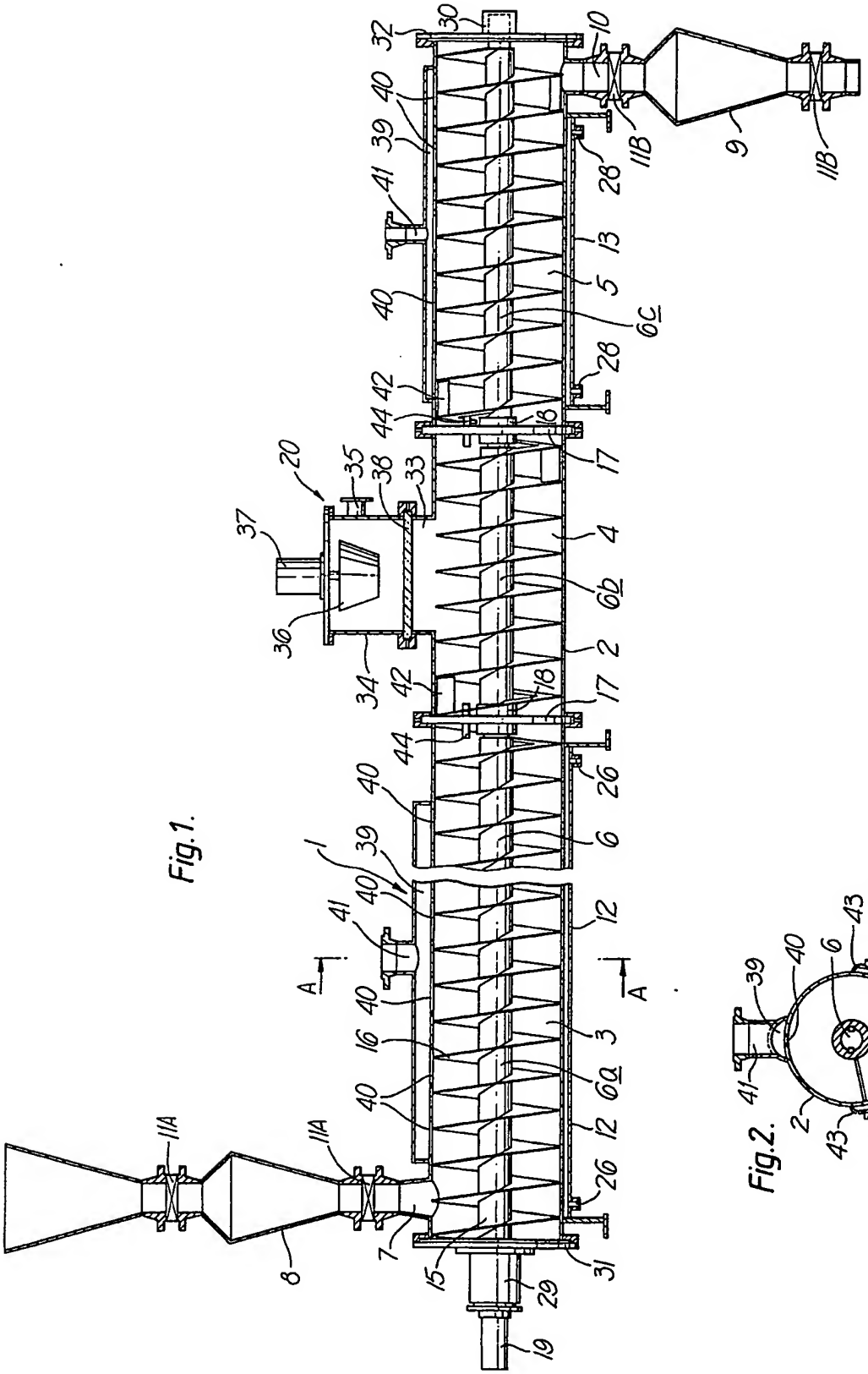

Fig.1.

Fig.2.

SPECIFICATION

Improved material treatment apparatus

The present invention relates to material treatment apparatus utilising a screw-conveyor for passing material to be treated through the apparatus.

Such material treatment apparatus is known wherein steam and/or hot water is used to heat the material and the apparatus may, additionally, include a subsequent cooling section both the heating and cooling sections may operate under vacuum conditions. It is the main object of the present invention to provide an improved conveyor material treatment apparatus for heating/drying, cooling.

According to the present invention material treatment apparatus having a screw-conveyor or the like for pregressing material through the apparatus includes a microwave section with at least that part of the screw-conveyor within the microwave section comprising material which has a low absorption for microwave energy and consequently does not substantially attenuate such microwave energy. More specifically said part can be substantially transparent to the microwave energy. Preferably both the shafting and vane means of said screw-conveyor portion are similarly transparent to microwave energy. Preferably also the microwave section is bounded by choke plates to reduce microwave energy losses and these choke plates may, if required, incorporate bearings for the screw-conveyor.

Preferably microwave energy is supplied to the microwave section via a chamber mounted on a casing housing the section, and a window is located between the chamber and the section whereby the chamber and section can function under different pressures.

The microwave section may supplement the steam and/or hot water section or may indeed replace it.

Again a cooling section can be provided and at least part of the screw-conveyor or portion in this section may also be of a material of construction which is essentially transparent to microwave energy.

In a preferred embodiment said screw-conveyor portion in the microwave and/or cooling sections can be made of a plastic material such as polypropylene.

An embodiment of the present invention will now be described by way of example with reference to the accompanying drawings wherein Figure 1 shows a sectional side view of the screw-conveyor dryer according to the present invention and Figure 2 shows a sectional end view of the dryer through section A-A in Figure 1.

Drying apparatus 1 serves to dry granular material which may have been wetted not only with water but with other solvents or their combinations, and the apparatus is particularly useful for producing products for the pharmaceutical and fine chemicals industries although not exclusively so. Apparatus 1 comprises an elongate closed shell 2 of cylindrical form housing a steam/hot water section 3, a microwave heating section 4 and a cooling section 5, and screw-conveyor section 6 extends from end to end In the shell 2 and serves to progress the material through the sections 3-5. A hopper 8 fitted with batch valves 11A feeds into inlet 7 of section 3 while a similar hopper 9 with batch valves 11B receives the material discharge from section 5 via outlet 10. The section 3 includes a semi-cylindrical heating jacket 12 located on the bottom half of the section (see Figure 2) and this jacket 12 includes an inlet 25 for heating fluid (steam/hot water) and a fluid discharge 26. The cooling section 5 includes a similar cooling jacket 13 located on the bottom half of the vessel and including an inlet 27 for cooling fluid (e.g. water) and a fluid discharge 28. The jackets 12/13 include appropriate air vents 43. Additionally means are provided to maintain a vacuum in the sections 3-5: a suitable value for the vacuum may be 0.51b/in^2 absolute but it is possible for the apparatus to operate at any degree of vacuum from almost atmospheric to full vacuum.

The screw-conveyor 6 includes separate portions 6*a*, 6*b* and 6*c* coupled together by appropriate means and each associated with a respective treatment section 3-5. The shaft 15 and spiral vane 16 of portion 6*a* can be made of stainless steel. On the other hand, it is an important characteristic of the apparatus that shaft 15 and spiral vane 16 of the portion 6*b* in the microwave section 4 are manufactured of a material which has a low absorption for microwave energy and consequently does not substantially attenuate such microwave energy. In particular it is arranged for the shaft and vane of the portion 6*b* to be made of material transparent to microwave energy, for example polypropylene, to facilitate the satisfactory absorption of microwave energy by the material being conveyed through the section 4. If required, the shaft section can be strengthened by a small diameter centre bar of stainless steel. Screw-conveyor portion 6*c* in section 5 can be made of any suitable material such as stainless steel and/or polypropylene. Microwave section 4 is bounded by choke plates 17 suitably apertured to permit passage of material and vapour between sections 3-4 and 4-5 while mitigating leakage of microwave energy from section 4 and additionally these plates 17 carry bearings 18 for the shafts 15 of screw-conveyor sections 6*a*-6*c*. The screw-conveyor 6 includes a projecting shaft portion 19 adapted for connection to a drive (not shown) such portion 19 being suitably glanded in feed end cover to prevent ingress of air when a vacuum is drawn in sections 3-5. Bearings 29, 30 for the screw-conveyor shaft 15 are also provided in end covers 31, 32 of the shell 2.

The microwave section 4 includes a single large inlet duct 33 for microwave passage into the section 4, and secured to the top of the duct 33 is a chamber 34 including an appropriate number of microwave injection branches (a single branch 35 is shown) which direct microwave energy into a mode stirrer 36 extending longitudinally in the chamber 34 and driven by motor 37, the mode stirrer 36 also serving to direct the microwave energy through the duct 33 into the interior of the shell section 4. A polypropylene window 38 is sealingly located between flanged

portions of the duct 33 and chamber 34, and enables the chamber 34 to remain at atmospheric pressure while the interior of the shell 2 is under vacuum conditions. The microwave energy can be produced by suitable microwave generating apparatus (not shown). The shell section 4 is preferably made of a material, for example stainless steel or aluminium, which would provide efficient reflection of microwave energy in the microwave cavity and minimise surface microwave energy losses.

The heating section 3 and cooling section 5 each include a manifold 39 located on the top of the shell 2, and elongate slots 40 on the shell 2 permit egress of vapours from the sections 3/5 into the manifolds 39. Vapour tubes 44 allow vapours from section 4 to pass to sections 3/5. Vapour is withdrawn from the manifolds 39 via outlets 41. Also the Screw-conveyor 6 includes lifter plate portions 42.

The use of the microwave section in the screw-conveyor drying apparatus considerably increases the drying effect of the apparatus. Optimum economies can be achieved by using the steam/hot water heating sections to remove the bulk of the moisture leaving the microwave section to remove the residual moisture. However, with certain materials to be dried, it would of course be possible to dispense with the steam/hot water section.

The above apparatus can be used for drying a wide variety of materials, and may also be used to dry preformed pastes.

Modifications are of course possible. For example the heating jacket of section 3 may be supplemented by a heating system wherein the shaft and vanes of the screw-conveyor in section 3 are of hollow construction allowing the use of steam/hot water for heating the conveyor shaft and vanes. A variety of microwave generating and launching systems are possible depending on the level of microwave power required and may be single unit or a multiplicity of units. Only part of the screw-conveyor section 6*b* may be of material transparent to microwave energy. Also, the feed hopper 8 may be replaced by an extruder device for feeding material into the heating section 3.

CLAIMS

1. Material treatment apparatus having a screw-conveyor or the like for progressing material through the apparatus, the apparatus including a microwave section with at least that part of the screw-conveyor within the microwave section comprising material which has a low absorption for microwave energy and consequently does not substantially attenuate such microwave energy.

2. Apparatus as claimed in Claim 1, wherein said screw-conveyor part is substantially transparent to the microwave energy.

3. Apparatus as claimed in Claim 2, wherein the screw-conveyor includes a rotatable shaft with material progressing vanes mounted on the shaft, the portions of the shaft and vanes within said microwave section being substantially transparent to microwave energy.

4. Apparatus as claimed in any one of the preceding Claims, wherein said screw-conveyor part comprises plastics material.

5. Apparatus as claimed in Claim 4, wherein the plastics material is polypropylene.

6. Apparatus as claimed in Claim 4 or 5 wherein the part of the screw-conveyor within the microwave section includes a reinforcing element.

7. Apparatus as claimed in Claim 6, wherein the reinforcing element comprises a metal rod located centrally in the screw-conveyor.

8. Apparatus as claimed in any one of the preceding Claims, wherein the microwave energy is supplied to the microwave section from a housing via an inlet duct, partition means being provided to enable the interior of the housing to be at a different pressure from the microwave section.

9. Apparatus as claimed in any one of the preceding claims, wherein a further treatment section or sections is provided additional to the microwave section, a choke plate being provided between each of said additional sections and the microwave section to reduce microwave energy loss.

10. Apparatus as claimed in Claim 9, wherein said additional section or sections comprises heating and/or cooling sections.

11. Apparatus as claimed in Claim 9 or 10, wherein the part of the screw-conveyor in an additional section is of different material from the screw-conveyor part in the microwave section.

12. Apparatus as claimed in any one of Claims 8 to 11, wherein the part of the screw-conveyor in an additional section is of the same material as that in the microwave section.

13. Apparatus as claimed in Claim 9, wherein the sections are housed in an elongate shell; and there are provided at least one semi-circular jacket on the bottom part of the shell for heating or cooling fluid, and at least one manifold mounted on the top part of the shell to receive vapour from any of the sections via aperture means on the shell, the manifold including a discharge outlet.

14. Apparatus as claimed in Claim 8, wherein a mode stirrer for microwaves is located within said housing.

15. Apparatus as claimed in Claim 8, wherein one or more inlet ducts is provided on the housing for the delivery of microwave energy.

16. Material treatment apparatus substantially as hereinbefore described with reference to and as illustrated in the accompanying drawings.

New claims or amendments to claims filed on 2 March 1983

Superseded claims 1

New or amended claims:-

1. Material treatment apparatus having a screw-conveyor for progressing material through the apparatus, the apparatus including a microwave section with at least that part of the screw-conveyor within the microwave section comprising material which has a low absorption for microwave energy and consequently does not substantially attenuate such microwave energy.

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